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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Industrial
Refrigeration Compressor
Lubrication

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A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Industrial Refrigeration Compressor Lubrication

WATER—next to air—the most vital essential to the existence of mankind, is of serious concern to many communities in the United States. In reality, the population and industrial developments in areas such as Metropolitan New York, Houston and Los Angeles have expanded far beyond the water impounding facilities in the watersheds serving these communities. But this article deals with refrigeration, not water. Then why the reference to water?

Simply because water must be used for cooling purposes in many industrial refrigeration and air-conditioning installations. Until the current worries developed as to water conservation, one-time usage of water prevailed in many refrigeration and air-conditioning plants. Lately, it is becoming more and more necessary that this water be re-used. This means that higher compressor temperatures will prevail because the heat exchange will not be as favorable when using the warmer cooling water from re-circulation cooling towers.

Higher compressor temperatures affect lubrication. Consequently, a review of prevailing practices in selecting refrigeration compressor oils is advisable. To complete the picture we will discuss:

Present day types of compressors as applied to
- ice cream handling
- food and meat preservation
- fur storage
- ice making
- air-conditioning

Conventional methods of lubrication.

Lubricating oil performance.

Pressure and temperature relationship.

Refrigeration oil characteristics and factors in selecting the most suitable oils.

TYPES OF COMPRESSORS

Industrial refrigeration compressors are of two types:

Reciprocating

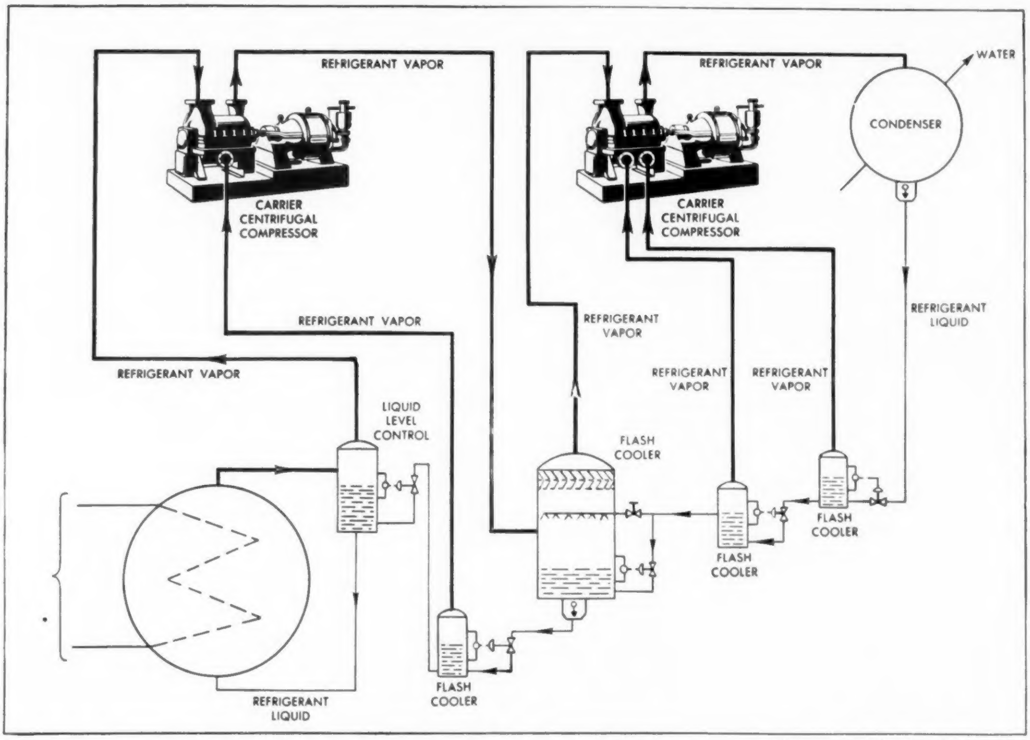
Centrifugal

The principles of refrigeration are the same; also, lubricating oil requirements are similar.

Reciprocating Machines

The vertical reciprocating type of compressor resembles the automotive engine to a certain extent, except that the number of cylinders is conventionally one, two or four, etc. according to the service. In either case, from a lubrication viewpoint, there are pistons, piston rings, main bearings, connecting rod bearings, crossheads, wrist pins and stuffing boxes.

In the household type of refrigerator or freezing unit, the smaller commercial jobs or some air-conditioning units, the compressor crankshaft may be



Courtesy of Carrier Corporation

Figure 1 — Carrier centrifugal compressors are well adapted to low temperature refrigerating cycles employing petroleum or halogenated hydrocarbons as refrigerants.

connected to the driving motor through belt drive or some other type of fixed coupling.

These smaller compressors also differ from the large tonnage industrial type in that piston rings are rarely used. Instead, the designers plan for close clearances between pistons and cylinder walls and depend upon the oil film to maintain the necessary seal.

The designers also make use of a distinctive method of drawing the gas to be compressed into the cylinders of the smaller machines. In contrast with the conventional manner of handling the gas in other types of compressors or engines, i.e. taking the charge from the topside as is customary in the gasoline engine or reciprocating air-compressor, the electric or domestic refrigerating compressor often draws in the low pressure refrigerant gas through the crankcase using valve mechanisms which are built into the piston or adjacent thereto.

Centrifugal Compressors

The centrifugal compressor is patterned after the centrifugal fan except that more than one impeller is involved. These impellers mounted on a central shaft comprise the rotor and bring about compression by virtue of the pressure due to the centrifugal effect and the action of the blades upon the gas. This gas is conducted from the peripheral outlet of one impeller to the center inlet of the next impeller or stage, the pressures being progressively increased until the gas leaves the final stage. During this action, there is no pulsation and the pressure increase is uniform.

In a centrifugal compressor the only parts requiring lubrication are the bearings of the rotor and the thrust bearing. Heavy duty plain bearings ring-oiled or force feed lubricated and a Kingsbury type thrust are used. Positive force feed lubrication is maintained by an oil pump submerged in the oil sump and driven off the rotor shaft by a worm and gear arrangement. An auxiliary oil pump (usually motor-driven) is provided to procure initial and slow-down lubrication while the compressor is coming up to speed or being shut down. This auxiliary pump cuts in automatically when the oil pressure is below the predetermined value.

There is very little chance for the refrigerant to leak into the oiling system due to the over-all design and the use of oil seals so the viscosity-reducing effect of halogenated refrigerants are rarely serious. A further advantage of centrifugal compression is the absence of small expansion valves, so the need for very low pour test or wax free lubricating oil is obviated, except where wax separation in the heat

exchanger of a low temperature system might occur to cause poor heat transfer.

DESIGN WITH RESPECT TO LUBRICATION

The heavy duty industrial compressor normally is designed for splash or force feed lubrication. Splash is applicable to the vertical reciprocating machine. Pressure or force feed, however, can be used to advantage on any type of unit. The objective in any case is to obtain positive circulation of oil (the volume of which is limited) with the least amount of foaming, although the use of foam depressants in the oils virtually eliminates foaming as a problem.

Splash Lubrication

Splash lubrication involves circulation of oil from the crankcase of a reciprocating compressor by the dipping action of the crank and the throw which the latter develops as it rotates. Oil level is important in a splash system; it must be high enough to permit the crank to dip and splash a generous amount of oil to the cylinder walls and bearings, but not too high or foaming may result in the case due to violent agitation of the oil. In reality, a well planned splash oiling system creates and maintains an oily vapor condition within the compressor which assures ample lubrication for all parts.

Re-charging of the crankcase with oil must therefore be done very carefully when the machine is idle to see that the oil level is not raised too high. Even though there may be no problem of foaming when suitable refrigeration grade oils are used, other objectionable results may occur from excessive agitation of the oil such as loss past the rings due to pumping, or the retaining of solid impurities in suspension.

Pressure or Force Feed Circulation

As in a splash system, the amount of oil in a pressure or force feed oiling system is fixed, according to sump capacity. Greater pressure, how-

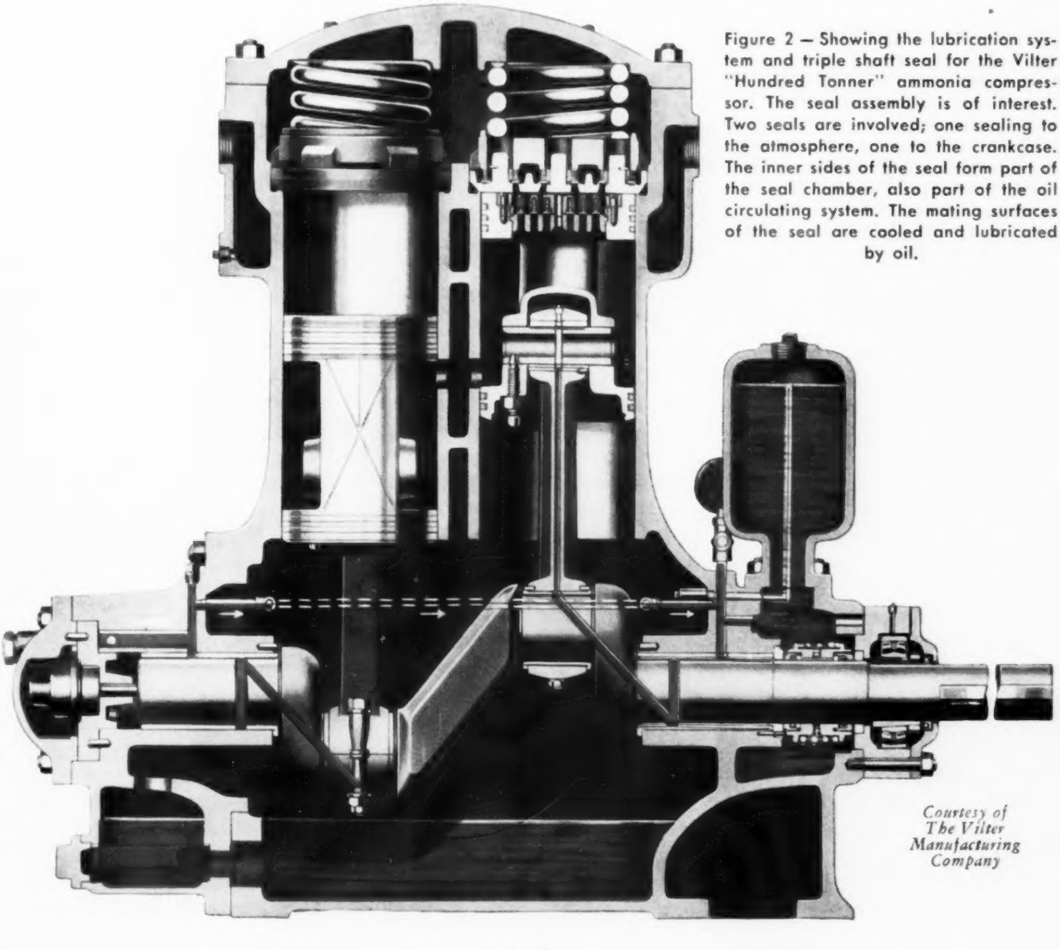
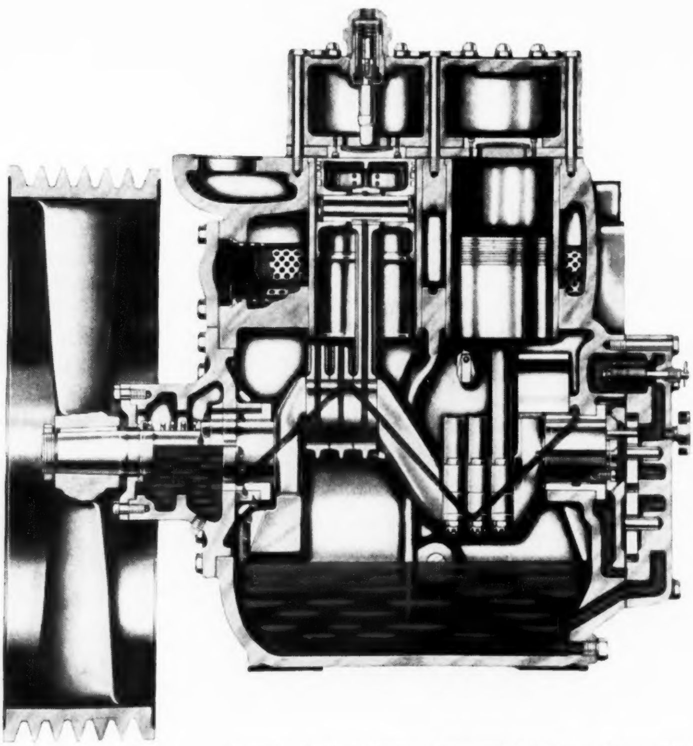


Figure 2 — Showing the lubrication system and triple shaft seal for the Vilter "Hundred Tonner" ammonia compressor. The seal assembly is of interest. Two seals are involved; one sealing to the atmosphere, one to the crankcase. The inner sides of the seal form part of the seal chamber, also part of the oil circulating system. The mating surfaces of the seal are cooled and lubricated by oil.

Courtesy of The Vilter Manufacturing Company



Courtesy of Worthington Pump and Machinery Corporation

Figure 3 — Longitudinal sectional view of a Worthington 6 cylinder Type HF "Freon" Compressor showing details of forced feed oiling system in red.

ever, is applied to the oil as it forms its films, also it can be accurately controlled. On the other hand, a pressure system is more costly due to the pump valves, piping and other fixtures which are required. To offset this first cost, however, is the fact that the oil can be filtered continually during service, to enable maintenance of lubricating value.

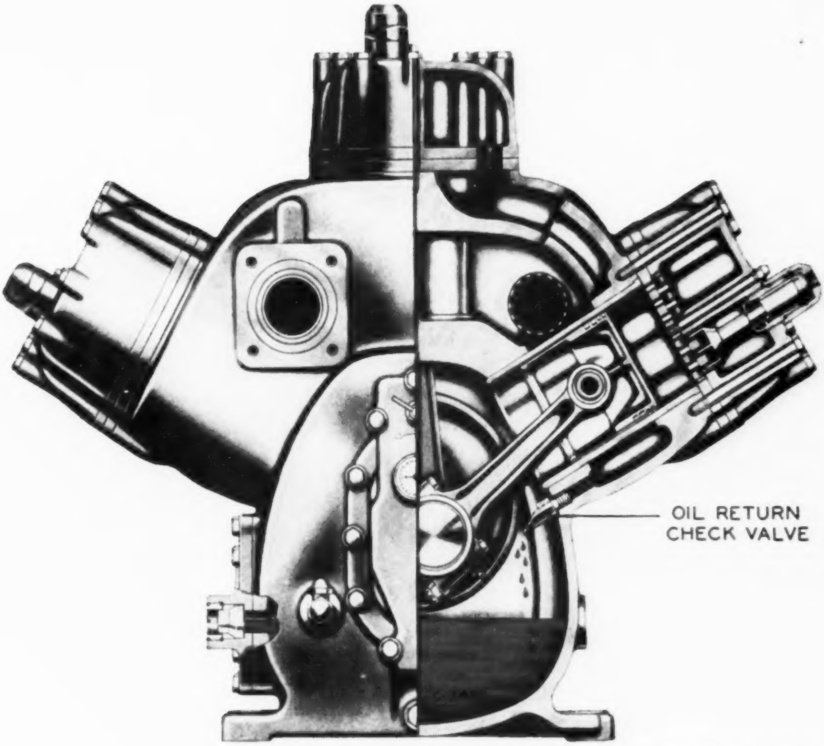
A gear pump similar to the automotive type is widely used to circulate the oil in a pressure oiling system. The typical gear pump, as designed for positive delivery of oil, is a comparatively simple device, consisting of a pair of gears mounted in a suitable housing. The normal location of such a pump is in the base of the crankcase, or in a sump tank adjacent or attached to the compressor block. Some designers prefer to place this pump at the lowest part of the machine. Others are of the opinion that the pump should be set just above a depression or catch basin in the case to provide means for trapping foreign matter and preventing it being circulated through the lubricating system, — however, there should be very little foreign matter in a well designed system using properly refined oil.

Irrespective of the location of the pump, however, suction is automatically maintained by gravity, since the pump is below the normal oil level. The discharged oil, under pressure according to the speed of rotation of the gears and their relative tooth dimensions is led from the discharge side of the pump to the bearings and other elements by drilled passages and suitable piping connections. As oil passes out from the bearing clearance spaces, or drips from the cylinder walls or other parts of the compressor housing, it returns to the case or oil sump by gravity for recirculation.

LUBRICATING OIL PERFORMANCE

Lubricating oil performance can be anticipated by the extent to which the physical properties of the oil are suited to the operating conditions. The Petroleum Industry performs a variety of tests upon lubricating oils, according to the intended service. In the case of refrigeration grade oils, viscosity, dielectric strength, pour test and wax floc are of most importance.

Lubricating oil performance, however, is also related to the chemical nature of some refrigerants in that certain of the latter cause reduction in viscosity and pour test when mixed with petroleum oils; others may promote corrosion in the presence of moisture.



Courtesy of Worthington Pump and Machinery Corporation

Figure 4 — Sectional view of a Worthington 6 cylinder Type HF "Freon" Compressor showing oil return check valve. Means for capacity control is located above suction valve.

To be specific, lubrication of a reciprocating compressor operating on any of the halogen derivatives of certain aliphatic hydrocarbons ("Freon" group) requires a thorough understanding of the fact that these refrigerants are entirely miscible with straight mineral lubricating oils. As a result of this characteristic there is a decided reduction in the viscosity of the ultimate mixture. At one time the trend in the Petroleum and Refrigeration Industries was to select a lubricant of considerably higher viscosity than would normally be called for in the lubrication of compressors of the same capacity operating on some of the other accepted refrigerants. Lately, however, certain authorities are of the opinion that the "Freon"-lubricating oil mixture, as developed in the operation of an air-conditioning unit, has some appreciable lubricating value, hence the higher viscosity oils are not thought so imperative.

There is no chemical reaction, between any of the "Freon" refrigerants or other halogen type materials, and petroleum lubricants specifically refined for refrigeration service. Sulfur dioxide on the other hand, in the presence of but only a trace of water will react chemically therewith to form corrosive acids. Where the lubricating oil has not been most carefully refined to render it as chemically stable as possible, there will also be a possibility of reaction of some of the hydrocarbons of such an oil with the sulfur dioxide. This will result in sludge formation and accumulation of gummy material which may seriously impair the operation of the unit and especially the distribution of the lubricant. High dielectric strength as an indication of freedom from water is, therefore, a most important property.

Foaming

Foaming, while not a chemical reaction, requires consideration whenever the oil is to be used in a sealed machine, where it functions as a coolant for the motor windings as well as a lubricant for the moving parts. Usually an excess of oil is circulated in machines of this type by means of a suitable pumping device. It is this excess which serves as the cooling medium during the course of circulation through the unit. Abnormal tendency to foam with the refrigerant will reduce this cooling effect. In addition, if too much foam accumulates an excessive amount of oil may be carried over into the receiver and the low pressure side of the system. Where foaming occurs in a pressure oiling system

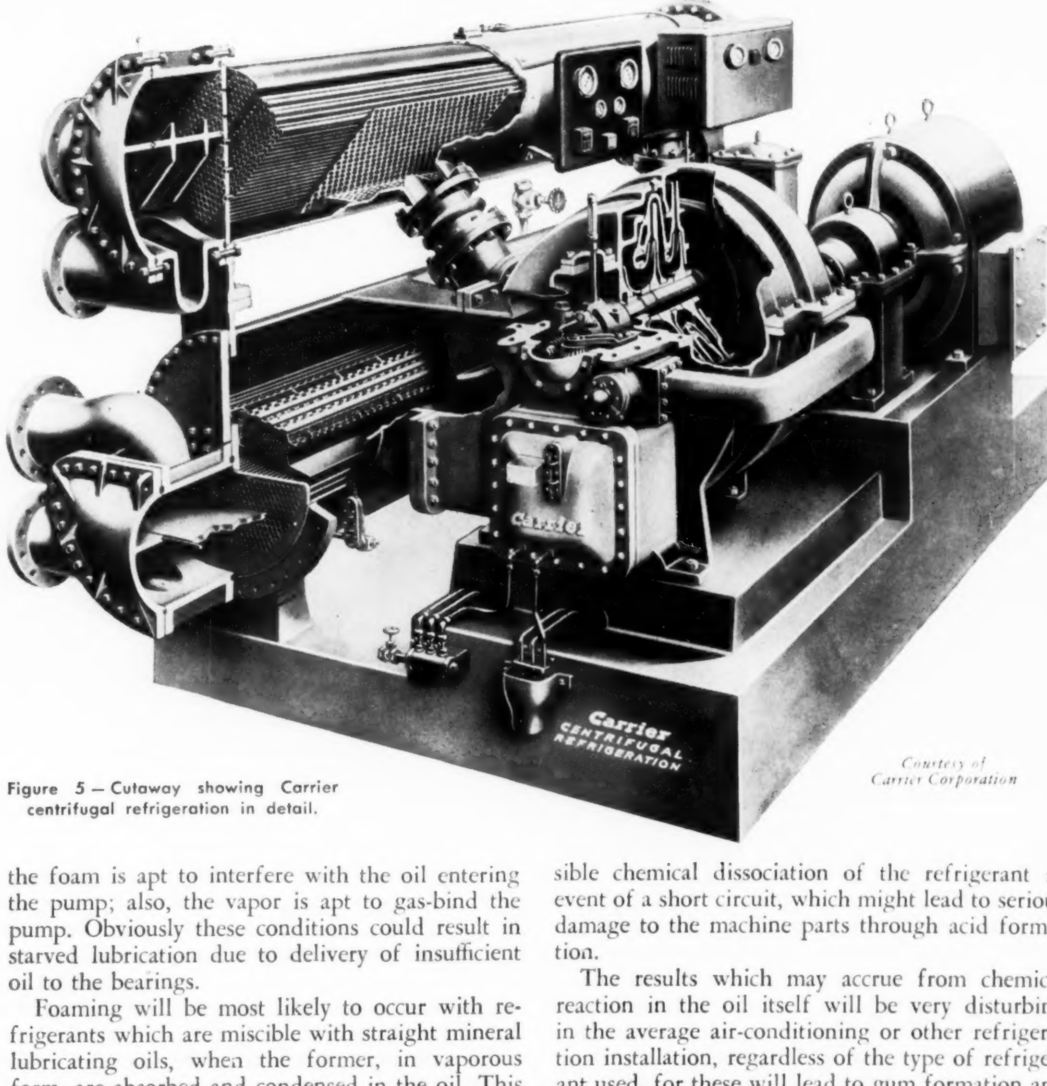


Figure 5 — Cutaway showing Carrier centrifugal refrigeration in detail.

Courtesy of Carrier Corporation

the foam is apt to interfere with the oil entering the pump; also, the vapor is apt to gas-bind the pump. Obviously these conditions could result in starved lubrication due to delivery of insufficient oil to the bearings.

Foaming will be most likely to occur with refrigerants which are miscible with straight mineral lubricating oils, when the former, in vaporous form, are absorbed and condensed in the oil. This becomes most evident if the unit is overcharged with oil, and there is possibility of excessive splashing or too active circulation.

Corrosion and Chemical Stability

The tendency which any petroleum lubricating oil will have to bring about the above reactions will be more or less a measure of the method and degree of refinement. In the interest of reducing the corrosion tendency it is especially essential that the water content be practically nil; this is also necessary to prevent freezing at the regulating valve and restriction of flow of the refrigerant. Water would also freeze in the cooling coils, to reduce evaporative efficiency. In the hermetically sealed machine a dehydrated oil is also advisable to prevent possible chemical dissociation of the refrigerant in event of a short circuit, which might lead to serious damage to the machine parts through acid formation.

The results which may accrue from chemical reaction in the oil itself will be very disturbing in the average air-conditioning or other refrigeration installation, regardless of the type of refrigerant used, for these will lead to gum formation and possibly actual stopping of the unit. Resistance to sludge formation can be determined by the chemist in terms of resistance to oxidation.

COMPRESSION RATIO, PRESSURE AND TEMPERATURE

Compression ratio can be a factor whenever lubrication of a refrigerating compressor is being considered. Compression ratio in refrigeration may be expressed as the ratio of absolute discharge pressure to absolute suction pressure, i.e.

$$\frac{P_2}{P_1}$$

Given 200 p.s.i. absolute discharge pressure (P_2) and 25 p.s.i. absolute suction pressure (P_1) there would be an 8:1 compression ratio.

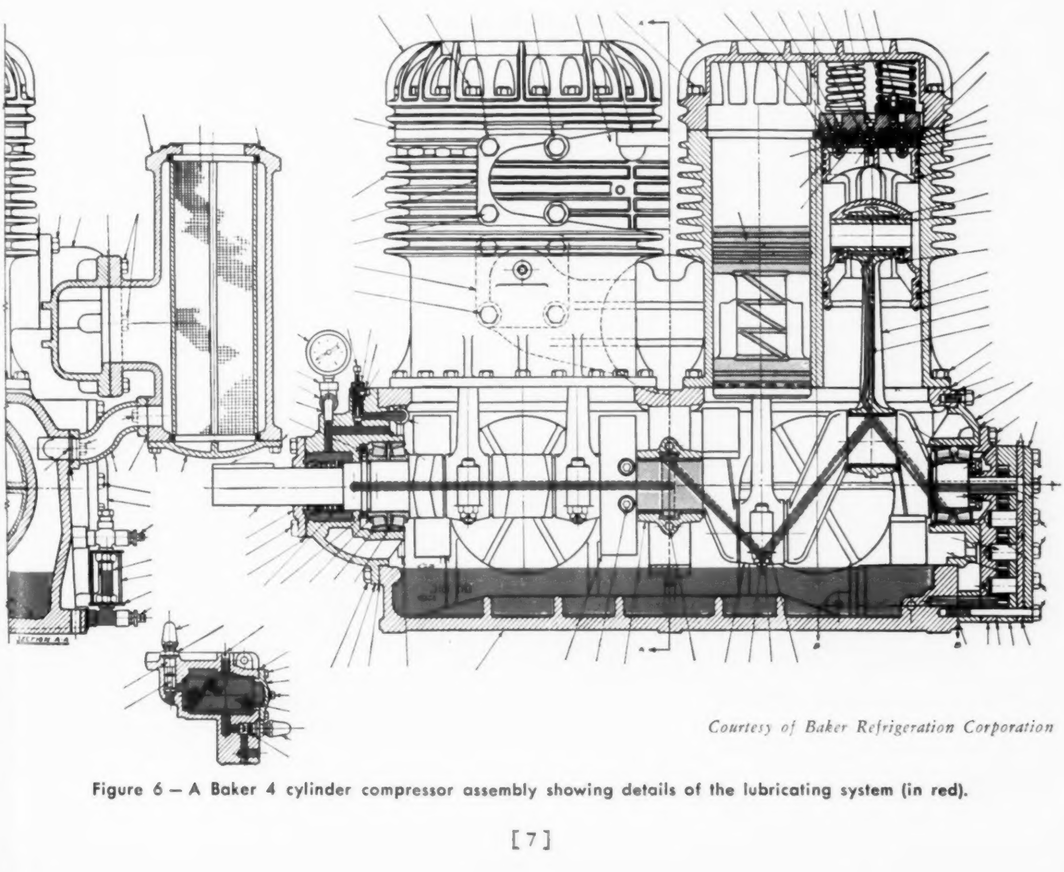
The suction pressure is set by the low refrigerant temperature to be maintained. The discharge is set by the type of condenser and type and temperature of coolant used. This sets the ratio of compression. In turn, compression ratio affects the compression temperature at the point of discharge of the compressed refrigerant from the compressor. In other words, a machine designed for a compression ratio of 10 to 1 would operate under a higher discharge temperature than one at 6 to 1, with comparable cooling water conditions such as rate of flow and inlet temperature.

Pressure Causes Temperature Rise

In view of the fact that the high and low pressure sides of a refrigerating system are so closely related to temperature, it is well to mention the dividing points. Normally these are the discharge valve in the compressor, and the needle or expansion valve adjacent to the evaporator. The refrigerant gas, after it has been compressed, is forced through the discharge valve into the condenser. Due to the work done on the vapor in compression the temperature is raised considerably above that of the surrounding media. Heat also is developed by the piston in the cylinder. Heat units, therefore, must pass from the gas to the cooling medium around the condensor tubes, which may be either air or water. In the condenser heat is extracted and the refrigerant gas is changed back or condensed into the liquid state, in which form it flows into the receiver or sump tank, and thence via a liquid line, through a needle or liquid control valve, a suitable float valve or an expansion valve.

From here on during the cycle we are dealing with the low pressure side. In other words, after the liquid refrigerant has passed the liquid or expansion valve, it is admitted into the cooling coil or evaporator as required, to replace the liquid refrigerant which has been evaporated. In the cooling coil or evaporator the liquid will expand or vaporize in accordance with the amount of heat which is carried to it from within the refrigerator. This heat-laden gas then passes via the suction line to the compressor for recompression and recirculation.

While dealing with the compressor, it is also interesting to note that it plays another part by virtue of its being able to change the pressure on the surface of the liquid refrigerant in the cooling unit. This, of course, will have a direct bearing on the temperature. This can be governed by a suitable pressure control or thermostat. Either of these lat-



Courtesy of Baker Refrigeration Corporation

Figure 6 — A Baker 4 cylinder compressor assembly showing details of the lubricating system (in red).

ter can influence the operation of the compressor within certain definite predetermined points, causing it to start operation as soon as the temperature has reached the higher limit, and to stop when the temperature has been reduced to the lower limit.

REFRIGERATION OIL CHARACTERISTICS

Lubricating oils for refrigeration compressors are specialty products, refined specifically to meet the operating conditions prevailing in refrigeration service. These conditions may vary widely. The refrigerant low temperature range may be from around plus 35°Fahr. to well below −100°Fahr. The maximum high side temperature may go as high as 350°Fahr. at the same time cooling water may vary according to locality. The possibility of moist air leakage may be a factor tending to reduce the dielectric strength of the oil.

To meet these conditions, petroleum lubricating oils are refined to certain viscosity ranges (according to the conditions set forth on page 9). This is the first and basic requirement — viscosity. It is not a quality indicator, however — simply an indication of that physical property — relative fluidity.

Quality is indicated by the resistance to wax particles "plating out" on expansion valves, and the low moisture content. The former is noted by the floc temperature, the latter by the dielectric strength. A floc test of −60°Fahr. or below and a dielectric strength of 25,000 volts or better are indicative of a well-refined refrigeration grade oil. All other tests, even for pour and cloud are more or less secondary and will fall in line with the viscosity range according to the base or crude stock involved.

The Floc Test

Cold exerts a markedly different effect upon petroleum lubricating oils, than it does upon simple fluids such as water. Simple fluids of this nature have fixed and accurately ascertainable freezing points at which a complete change from the liquid to the solid phase takes place. Petroleum oils, however, being complex mixtures of hydrocarbons of various melting or freezing points, behave like solutions and frequently precipitate some portion of their hydrocarbon constituents before the whole mixture solidifies. This explains the wax haze and floc which are observed when such oils are chilled to very low temperatures.

The cloud and pour tests — forerunners of the haze and floc tests, — sufficed when petroleum lubricating oils were to be used for normal ice-making or cold storage refrigeration, but for lower than average service when capillary tube expansion valves

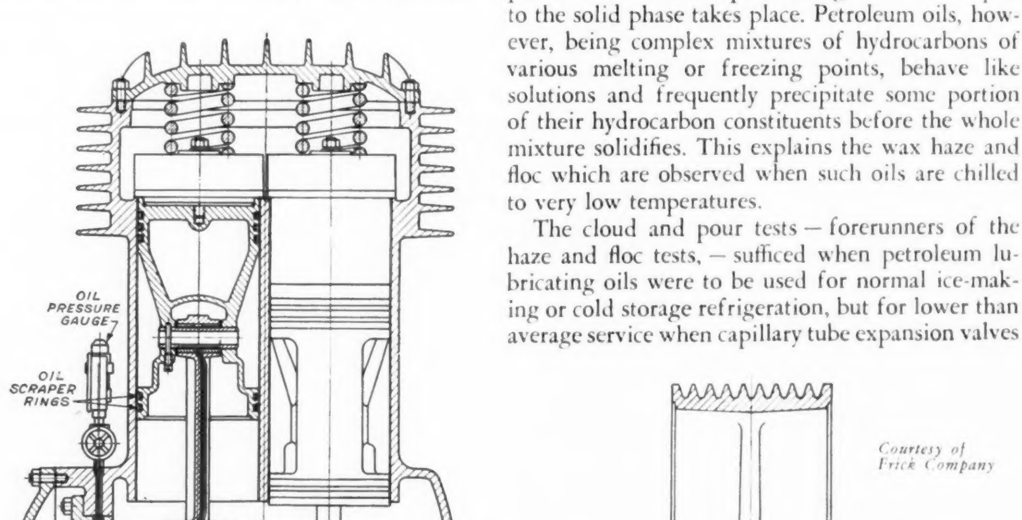
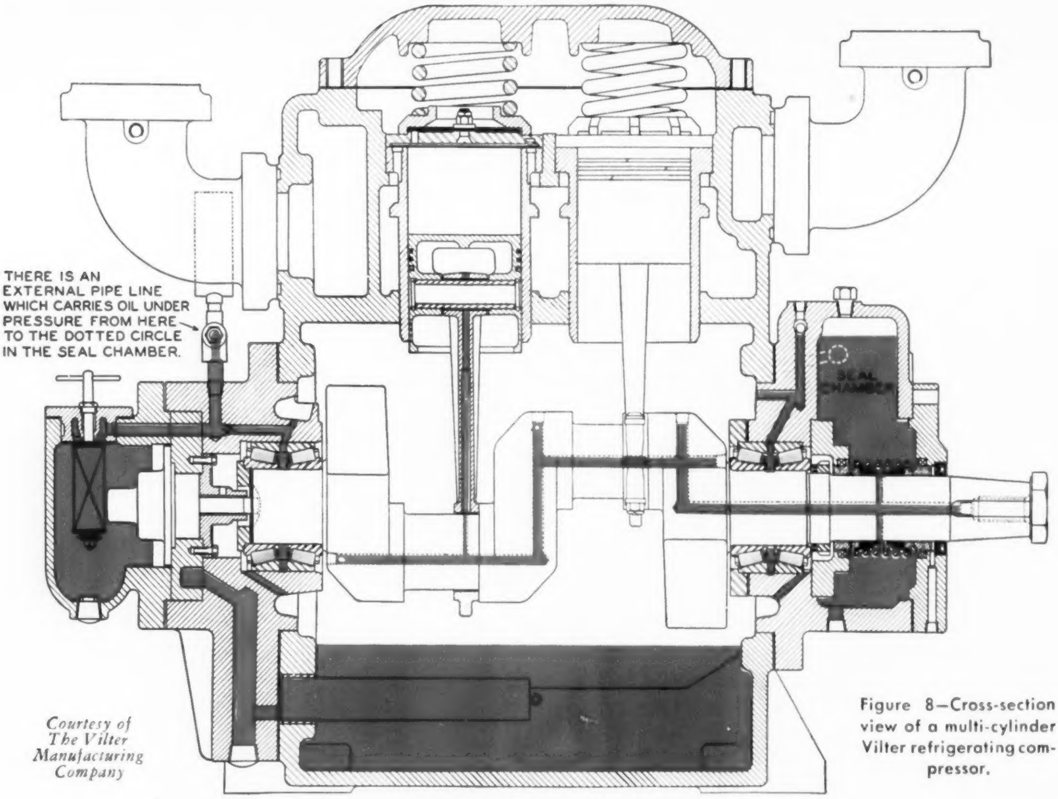


Figure 7 — Lubrication system for a Frick 2 cylinder "Freon-12" vertical reciprocating compressor. Oil enters the gear pump through the combs of the filter. The pump is driven by a chain and sprockets from the crankshaft. The main flow of oil goes upward to the outer bearing, above which a branch leads to the pressure gauge and relief valve for regulating the pressure. Opposite the chain a branch is taken off to the inner bearing and shaft seal. The rings on the lower part of the piston are of the oil scraper type, with ports behind them for draining the oil back into the crankcase.

REFRIGERATION COMPRESSOR — SERVICE CHART

Service	*Evaporator Temperature (Low Range) °F.*	*Type of Compressor*	*Refrigerants Most Widely Used*	*Compression Ratio*	*Discharge Line Temperature, °F. Observed*	*Discharge Line Temperature, °F. Calculated*	*Lubricating Oil Viscosity Range Sec. Say. Univ. 100 °F.*
Ice Cream Hardening and Storage	−20 to −30° F. Hardening	Reciprocating	"Freon-12"	From 4 to 10	275	325	150-200
	0° F. Storage		"Freon-22"	From 4 to 10			150-200
	25° F. Cooling		Ammonia	From 7 to 12	300	350	150-300
Food or Meat Freezing	−20 to −30° F. room storage −40 to −50° F. refrigeration	Reciprocating	"Freon-12" "Freon-22" Ammonia	From 4 to 8	175 to 200	225 to 350	150-300
	Ditto	Centrifugal	"Freon-12"	4 per stage	125	175	300
Fur Storage	Holding: 35° room temp. 10° refrigerant Killing: 15° room temp. −5° refrigerant	Reciprocating	"Freon-12" Ammonia	From 5 to 8	225	300	150-300
Ice Making	16° Brine 5° Ammonia	Reciprocating	Ammonia	From 4 to 8	250	300 to 350	150-300
Air-Conditioning	30° to 50° F. refrigerant 70° room temp.	Reciprocating	"Freon-12" "Freon-22"	From 3 to 5	175	225	300-500
		Centrifugal	"Freon-11"		125	175	300



Courtesy of The Vilter Manufacturing Company

Figure 8—Cross-section view of a multi-cylinder Vilter refrigerating compressor.

are used, cloud and pour tests are only roughly indicative of how the oil will behave at temperatures 30 to 40 or more degrees below the temperatures at which cloud may form and the oil ceases to pour. When an oil has been refined or processed so as to remove or change the structure of its wax content, dependable performance is more nearly assured regardless of its observed pour test. The floc test was designed to measure quantitatively this wax content. In effect, it is a wax precipitation test. It is made on a 10 − 90% mixture of oil and "Freon-12", at gradually reduced temperatures until the first faint haze is observed.

The temperature at which this occurs is recorded as the wax haze temperature. Then the temperature of the mixture is reduced further until the tiny wax crystals forming the haze, gather together in observable flocs. The temperature at which this occurs is recorded as the floc test.

It is important to note that the tiny haze-forming crystals are not in themselves harmful. The warning temperature is that at which these crystals begin to flocculate into clumps. This would indicate that undesirable waxy deposits and clogging might occur in capillary tubing or expansion valves at or below this temperature.

Current Research Activities

Current research in the study of the low temperature characteristics of refrigeration oils is being directed towards duplicating very severe operating conditions. It is generally recognized that laboratory tests at best only give indications of how a lubricant may perform in actual service. Consequently, the consumer should use discretion in selecting oils, giving due consideration to the significance of the tests and test limits that are included. If this is not done, oils may be eliminated from consideration that would be entirely satisfactory for the intended application. It is much better to judge the quality of a lubricant by means of actual service tests under controlled conditions rather than solely on the basis of physical tests run in the laboratory.

Reputable oil refiners run continuous manufacturing control tests on all their products to insure the marketing of uniform materials. The tests and test limits adopted for this purpose give assurance that the various refining operations are being conducted satisfactorily and that the end product is of uniform quality. Some of these refinery control tests will not necessarily be correlated so far as actual service performance is concerned and may vary from one oil refiner to another due to the use of

different crudes, processing procedures and processing conditions. Water separating tests appear to fall in this category. Moisture content must of necessity be maintained very low in refrigeration systems; hence, results obtained with the conventional water separating tests lose their significance except as possible refining control limits.

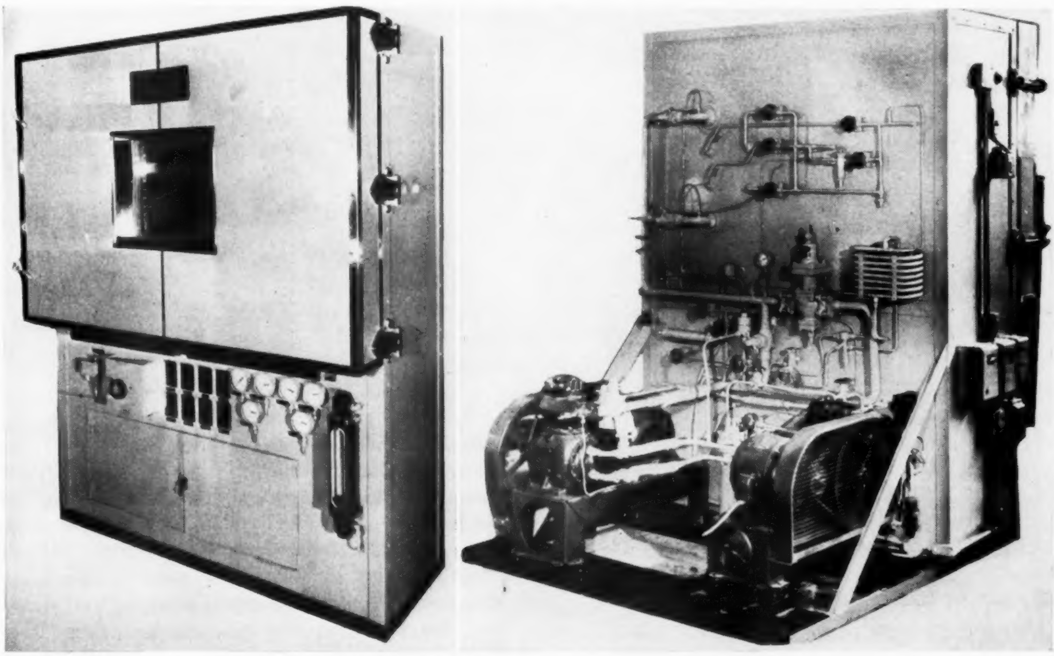
Laboratory wax precipitation tests may be similarly misleading. Their use, therefore, as a major criterion of quality for refrigerator oils must be approached with caution when interpreting the results obtained due to the inability to correlate them completely with service. As an example, an oil producing a wax haze by such a laboratory test in the neighborhood of −20°F. had given satisfactory service for a number of years in actual systems equipped with oil separators and operating at temperatures of some 50-60°F. lower. Use of the oil separator apparently reduced the concentration of oil circulating with the refrigerant to such an extent that very little if any wax was precipitated even at these very low temperatures.

In another instance difficulty was encountered with a "Freon-12" system operating at −60°F. which could not be eliminated by using a specially prepared oil showing a wax haze of −75°F. in the laboratory test. It was found that the difficulty being experienced was actually due to "oil logging" of the evaporator coil rather than to any wax plugging. By special processing, an oil was prepared with a wax haze of only −40°F., as measured by the laboratory test, yet it gave satisfactory performance at −60°F. even after an extended period of operation.

The Detriment of Water

When a refrigeration grade oil comes in contact with certain types of refrigerants, any moisture present will tend to accelerate corrosion, promote the formation of detrimental deposits or, even enter directly into chemical reaction under certain conditions of pressure and temperature. Hence the adoption of a high dielectric strength requirement as part of the usual purchasing specification for refrigeration oils. An appreciable amount of water in any such system might also cause stoppage of the expansion valve due to freezing; ice formations in the cooling coils would also be a possibility, an occurrence which would reduce evaporative efficiency.

Moisture in refrigerating compressor service will be most likely to cause corrosion when sulfur di-



Courtesy of Tenney Engineering, Inc.

Figure 9 — (Left) Front view showing controls of a Tenney refrigeration unit designed for laboratory use to simulate operating conditions of varied intensity in the study of refrigeration lubricating oils. (Right) Rear view of the same unit. Note the location of the compressors which can be operated with either "Freon-12" or "Freon-22" to develop cabinet temperatures as low as −100° Fahr. Facilities included enable operation with either pressurized or non-pressurized crankcases, with or without oil separators, with or without dehydration, using various types of expansion devices, also various types of evaporator coils.

oxide is being used. Sludge or objectionable deposits may in turn be experienced with ammonia, methyl chloride, Carrene and the "Freon" group in the presence of excess moisture.

The initial charges of such refrigerants and oil, therefore, must be virtually water-free, and care must be taken to prevent the occurrence of leaks which might lead to entry of moisture-laden air and subsequent condensation of moisture. All this, of course, becomes a function of the manufacturer in the original design and construction of the unit and the service man in its maintenance. In turn, it becomes the function of the manufacturers of the refrigerants and lubricating oil to prepare their products so that these will also be as dry as possible.

Where water cannot be entirely removed, it may be necessary to use a desiccant or to add a small amount of anhydrous methyl alcohol as an anti-freeze. Alcohol, however, can best be regarded as a remedy, not a cure. Furthermore, most alcohols are not anhydrous, so careless action on the part of a service man may lead to introduction of sufficient water with the alcohol to subsequently cause serious deposits to develop. The presence of alcohol, even in its purest form, may also be objectionable, as it adds another chemical to the already complex assortment which is presented by the refrigerant, the lubricating oil and the usual metals employed in the system.

Dielectric Strength

Moisture content in petroleum lubricating oils became of consequence with the development of the electric transformer, and the use of light viscosity lubricating oils for insulating and cooling purposes. Obviously, such oils had to show maximum insulating qualities; water would reduce these materially. The test developed was of an electrical nature. It determines the absence of water by the resistance offered to passage of electric current. Petroleum oils are excellent non-conductors of electricity when virtually free from entrained moisture; under such conditions only a negligible amount of current can pass. So the test procedure involves subjecting the oil under consideration to high voltage in a standardized test cup fitted with fixed gap electrodes of copper or brass. Resistance of oils to a stress of at least 21,000 volts per millimeter was found to be an indication that they were sufficiently dry for transformer purposes.

With the advent of methods of refrigeration requiring oils of like dryness, this test for dielectric strength (to a minimum of 25,000 volts) became of equal value to the petroleum chemist in refining and treating his lubricants for compressor service. Minute traces of moisture or solid materials have a very definite effect on reducing the dielectric value of an oil. In refinery procedure the presence of any of these materials is virtually eliminated by filtration. A variety of materials can be used for filtration. Filter press methods have proved to be most dependable, using a special grade of filterpaper for moisture absorption.

Care in Handling to Prevent Moisture Absorption

Petroleum oils which have been actively dehydrated will tend to re-absorb a certain amount of moisture when exposed to the air for any length of time. This will result in reduction of their dielectric strength, dependent upon the relative humidity of the air, the temperature range and the length of time they have been so exposed. They should, therefore, be carefully stored and the containers opened only when it is necessary to use the oil; subsequently, if any oil remains unused the containers should be sealed as tightly as possible using special air-tight replaceable tops when cans are involved, or sealing gaskets on metal drums. Before usage it is always advisable to keep containers of oil at room temperature, or the temperature of handling, for at least twenty-four hours. This will assure of an equalized temperature, and will reduce the possibility of moisture condensation in the oil and impairment of its dielectric strength. It, of course, is practicable to bring back the dielectric strength by refiltration through specially dried blotting paper but this is a costly procedure and it should not be necessary if the oil is properly handled.

CONCLUSION

The purpose of the foregoing discussion has been to bring out the fact that refrigeration machinery must be lubricated effectively if it is to operate economically. This fact is realized by the builders of refrigeration compressors their service people, the operators and the Petroleum Industry. The degree of cooperation which prevails among these groups in their approach to the solution of the ultra-low temperature requirements which are becoming more and more exacting today, is a highlight in industrial progress. Refrigeration, also, is a vital process in petroleum refining, requiring ultra-low temperatures. It has been logical, therefore, for the petroleum chemist and lubrication engineer to take this performance of refrigeration lubricating oils so seriously.

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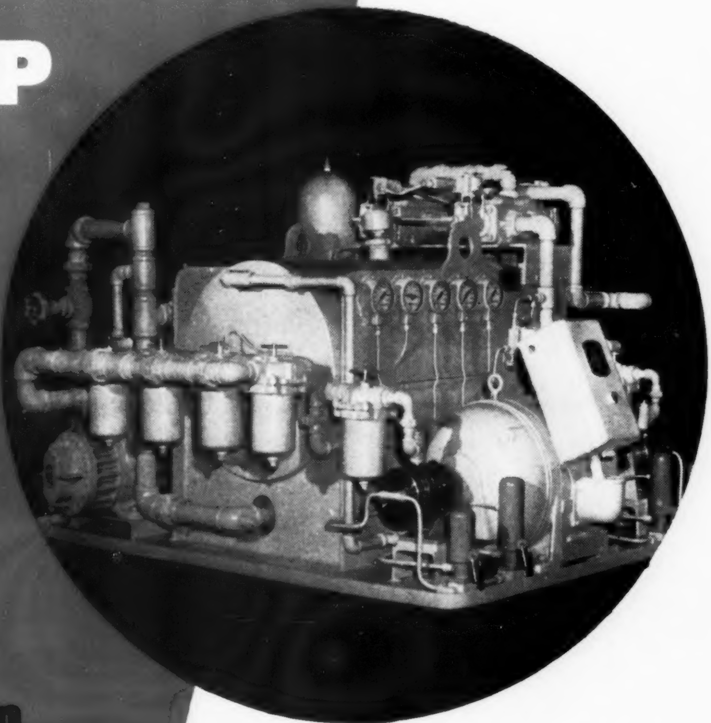

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